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REVIEW ARTICLE

Review of crisis resource management (CRM) principles in the setting of intraoperative malignant hyperthermia

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Abstract The practice of medicine is characterized by routine and typical cases whose management usually goes according to plan. However, the occasional case does arise which involves rare catastrophic emergencies, such as intraoperative malignant hyperthermia (MH), which require a comprehensive, coordinated, and resource-intensive treatment plan. Physicians are expected to provide expert quality care for routine, typical cases, but is it reasonable to expect the same standard of expertise and comprehensive management when the emergency involves a rare entity? Although physicians would like to say yes to this question, the reality is that no physician will ever amass the amount of experience in patient care needed to truly qualify as an expert in the management of a rare emergency entity, such as MH. However, physicians can become expert in the global process of managing emergencies by using the principles of crisis resource management (CRM). In this article, we review the key concepts of CRM, using a real life example of a team who utilized CRM principles to successfully manage an intraoperative MH crisis, despite there being no one on the team who had ever previously encountered a true MH crisis.

Keywords Anesthesia · Communication · Crisis management · Clinical decision support · Leadership

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Introduction

The practice of medicine is generally characterized by the clinical management of a preponderance of "routine" cases and of the occasional noteworthy cases, with only rare encounters of extreme cases with potentially catastrophic consequences. Malignant hyperthermia (MH) is a very rare and potentially lethal medical condition that presents as an medical crisis and requires comprehensive, coordinated, resource-intensive treatment. Since the incidence of this potentially deadly entity is quite low [1], few clinicians will actually ever care for a patient experiencing HM during their training or even over the entire course of their career.

The earliest signs of MH are generally non-specific, which can make MH very difficult to diagnose [2]. However, perhaps an even more important point to make is that even comprehensive medical knowledge and technical skills may not be sufficient to effectively treat patients experiencing an emergency such as MH. Often, it is the non-technical skills (e.g. communication, leadership, teamwork) of a team which make the difference between a successful and an unsuccessful patient outcome [3, 4]. Significant and specialized resources, both of equipment and personnel, are required to successfully manage critical situations like an intraoperative MH crisis. This is also true for other rare, but serious, perioperative emergencies, such as venous air embolism, tension pneumothorax, and maternal cardiac arrest. Such emergencies are fortunately so rare that no anesthesiologist is likely to ever amass enough personal clinical experience in managing each one to be considered a true expert [5]. However, clinicians can become experts in the global process of managing emergencies by mastering a specific set of skills called crisis resource management (CRM).

Table 1 Application of crisis resource management principles in the setting of intraoperative malignant hyperthermia

CRM principle	Examples from intraoperative malignant hyperthermia case
Anticipation	The attending anesthesiologist and resident discussed the possible causes of hypercarbia, including MH, at a beginning of the operation when the patient had an unexpectedly high $ETC0_2$. The code cart was summoned before any major dysrhythmias occurred
Calling for help	A second anesthesiologist was called to assist when the early, nonspecific abnormalities (i.e., hypercarbia) persisted despite seemingly appropriate therapy
	The subsequent helpers ("hands helpers") that were ultimately called completed tasks such as reconstituting dantrolene, administering medications, and placing a urinary catheter
Leadership designation	The attending anesthesiologist identified herself as the leader when it became apparent the patient was in an MH crisis. She remained as free as possible from physical tasks so as to allocate all attention to leadership of the team
Role clarity	Upon arrival of the additional help, physicians and nurses were each delegated a specific role by the team leader. No helpers were idle or unclear as to their responsibilities
Allocation of attention	To reduce the cognitive load and allocate attention in the most appropriate way, the team leader delegated each team member to complete specific tasks and to report back the status. One example was to collect and send an arterial blood gas, to follow up with the results, and to report the information back to the team leader when the results were available
Use all available information	Several members of the team reported the multiple streams of information back to the team leader including items, such as urine output quantity and color, changes on the electrocardiogram, dosing of medications given, and the availability of additional resources requested. As well, the leader continually solicited input from team members by asking if anyone had other ideas
Distributing workload	An attending anesthesiologist who was skilled in central line placement was assigned the role of getting additional intravenous access. Additionally, nursing team members were given the role of mixing the dantrolene. Personnel were given tasks according to their expertise and abilities, even if outside of their usual roles
Effective communication	The team leader continually kept the team apprised of the patient's status, including a summary of the patient's changing status, therapeutic steps that had been taken, the patient's response to therapy, and consideration of other team member's suggestions. Helpers "closed the loop" when communicating with the leader
Mobilize resources	The specialized resources to properly handle the MH crisis were not immediately available in the operating room, so a nurse was deployed to obtain the MH cart, which contained dantrolene and the supplies needed to reconstitute it, the MHAUS treatment algorithm, and other emergency medications, from the designated storage corridor
Cognitive aids	A first-year anesthesiology resident was delegated to consult the MHAUS cognitive aid for a MH crisis and review the treatment recommendations aloud with the leader. A second attending anesthesiologist offered early decision support
Knowing the environment	Since charcoal filters are rarely used, the team leader delegated an anesthesia technician familiar with the location of these items to obtain them rapidly and place them on the anesthesia circuit

CRM crisis resource management, *MH* malignant hyperthermia, $ETCO_2$ end-tidal CO_2, *MHAUS* Malignant Hyperthermia Association of the United States

Here, we present a case of a relatively healthy man who had a very brief, minor surgery and developed an intraoperative malignant hyperthermia crisis. We then review core concepts of emergency management skills and illustrate the effective deployment of those skills using the case scenario (Table 1).

Case scenario

Preoperative information

A 50-year-old man with a 2 × 2-cm ulcerated burn on his right forearm presented to the operating room for debridement and partial-thickness skin xenograft placement. His medical history was notable for obesity (101 kg) and cigarette use of 0.5 packs per day. His past surgical history consisted of a knee arthroplasty and hernia repair, for which he stated he had no anesthetic complications. His only medication was oxycodone, which he was taking for the pain related to his burn. On physical exam, the patient had normal heart sounds, clear lungs bilaterally, and an unremarkable airway exam.

Intraoperative course

Prior to arrival in the operating room (OR), the patient received midazolam for anxiolysis. For induction of anesthesia, he received fentanyl, lidocaine, and propofol. After hand-bag-mask ventilation was established, vecuronium was given to facilitate endotracheal intubation, which was uneventful. Anesthesia was then maintained with the inhalational anesthetic isoflurane. Immediately after intubation, there was an elevation of the end tidal-CO_2 ($ETCO_2$) to 60 mmHg, along with a capnogram pattern consistent with obstructive disease and his smoking history. His mechanical ventilation settings were subsequently altered to normalize the $ETCO_2$ to 40 mmHg, and it remained at this pressure for the duration of the 30-min operation.

During the placement of the surgical dressings, the patient's heart rate increased to 110 bpm, which was not unexpected during this period since the inhalational anesthetic concentration had been decreased in preparation for emergence and endotracheal extubation. Despite the generation of spontaneous respirations with appropriate minute ventilation, the patient's $ETCO_2$ gradually increased and his oxygen saturation started to decrease to the upper eighties. This was initially attributed to his presumed obstructive pulmonary disease. However, the tachycardia and hypercapnia persisted, along with the development of occasional premature ventricular contractions (PVCs). At this point, the anesthesia team elected to re-anesthetize the patient with propofol, fentanyl, and dexmeditomidine in an effort to normalize his vital signs prior to re-attempting emergency procedures. Concurrently, the anesthesia care team worked to rule out other causes that could explain these derangements (e.g. checking the position of the endotracheal tube, auscultation of lungs for bronchospasm, suctioning the endotracheal tube for secretions). Finding no other immediately apparent cause and observing an increasing rate of PVCs on the electrocardiogram, a code cart was summoned to the OR as a precaution, and an additional anesthesiologist was called to the room to help in diagnosis and treatment. Abruptly, the patient's electocardiogram (EKG) changed from sinus tachycardia of 120 with PVCs to ventricular bigeminy with ST segment depressions, and then subsequently into a ventricular escape rhythm of 28 bpm for approximately 60 s. Before any treatment could be administered, the patient's heart rhythm returned to sinus tachycardia of 120 with frequent PVCs. At this point in time a resident anesthesiologist was instructed to place an arterial line and obtain an arterial blood gas. However, the resident noted that the forearm was fixed in a pronated position and could not be supinated. Further inspection demonstrated profound rigidity of all of the patient's limbs. Due to the refractory hypercapnia, EKG abnormalities and profound rigidity in the setting of an agent (isolfurane) with the potential to trigger MH, a presumptive diagnosis was made and treatment was immediately initiated.

Crisis resource management

The earliest call for "anesthesia crisis resource management" (ACRM) came in the early 1990s when anesthesiologist David Gaba asserted that "ACRM training should become a regular part of the initial and continuing education of anesthesiologists" [6]. Over the past several years CRM concepts have started to permeate medical education for trainees and for board-certified anesthesiologists [7]. In this section, we will review core concepts of CRM (Fig. 1) and explore how they were used to achieve the positive patient outcome that is described above.

CRM is a set of concepts that focus not on drugs, physiology, or equipment, but rather on the thought processes and decision-making behaviors of the anesthesiologist, particularly during times of crises or emergencies. Because the nature of anesthesiology is dynamic and often unpredictable, there are times when decisions must be made in the setting of generalized uncertainty. Coupled to this uncertainty are the pressures of time-sensitivity and the stress of a high-stakes patient outcome. Consequently, possessing the knowledge and technical skills in perioperative medicine are not on their own enough to completely and effectively manage emergency situations and direct a team. Additionally, it is important to understand that the terms used to describe the principles of CRM below are in fact "simple"—but this simplicity should not be mistaken in this case for ease of performance or behavior that comes naturally to all healthcare providers. "Simple" concepts, such as effective communication and avoidance of fixation errors, are often not adequately understood or effectively implemented during emergencies [8]. Indeed, they top the list of The Joint Commission's (organization that accredits health care organizations in the United States) root cause analysis of sentinel events year after year [9]. Below is a discussion of the core CRM principles and how they were applied during unfolding of the case scenario presented above.

Anticipation

Anticipating future patient states and having a high index of suspicion for evolving problems is a hallmark of situational awareness [10], which has been defined as "developing and maintaining an overall dynamic awareness of the situation based on perceiving the elements of the theater environment: patient, team, time, displays, equipment, understanding what they mean and thinking ahead about what could happen in the near future" [11]. Fioratou and colleagues have taken this concept of situation awareness a step further and recommended "distributed situation awareness" which they describe as the interplay among the anesthesiologist, other team members, the patient, and the external environment [12]. An example of anticipation which has diffused throughout healthcare settings and resulted in reductions in in-hospital mortality, is the "rapid response team" or other groups that may be called to respond to "pre-code" events.

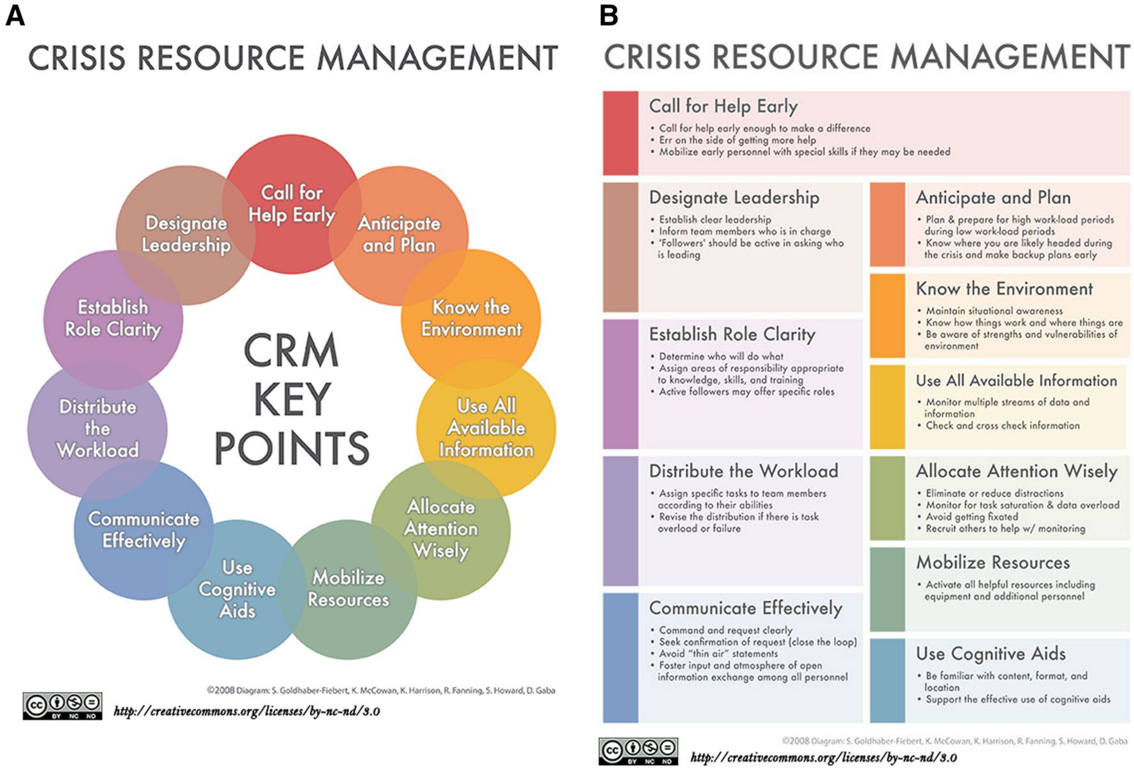

Fig. 1 **a** Eleven key points to crisis resource management (*CRM*). Reprinted without modifications from Goldhaber-Fiebert et al. (Available at: http://emergencymanual.stanford.edu/show.html). **b** Detailed description of the 11 key points to CRM. Reprinted without modifications from Goldhaber-Fiebert et al. (Available at: http://emergencymanual.stanford.edu/show.html)

In other words, when a nurse or other healthcare provider detects that a patient's condition is deteriorating, but they have not yet gone into cardiac or respiratory arrest, the anticipation that such an arrest could happen in the near future without intervention is a potentially life-saving effort [13]. Similarly, the recognition that a patient is possibly about to have a problem, rather than waiting for a problem to definitively present, may improve event management and outcomes in the operating room. Exemplified in the case scenario, the attending anesthesiologist and resident actually discussed the various possible causes of hypercarbia, including MH, at the beginning of the operation when the patient had an elevated $ETC0_2$ and obstructive respiratory physiology. This was done well before it became clear that the patient was suffering from a non-routine acute event, as part of habitual vigilance and the principle of anticipation [14].

Leadership designation and role clarity

Many physicians have had the experience of arriving to help a colleague only to find a scene of chaos. One of the most critical first actions in any crisis or emergency is to designate a leader and explicitly announce that leadership to the team. If a "helper" arrives and no leader is apparent, one of the most helpful actions that can be taken (regardless of medical specialty or seniority) is for the helper to request or designate a leader. Helpers can potentially impact the success of an event by doing just that, and this action often results in a more orderly and decisive continuation of the event. Similarly, leaders should clearly designate the roles for each task and include two components in those designations: (1) clear delegation by name, which is confirmed via a verbal callback from the intended recipient of the communication ("closed loop communication"), and (2) explicit instruction that the helper is responsible for following up and conveying the results when appropriate (e.g. "The labs are back. Are you ready to hear the results?"). Distributing the workload among helpers is critically important to preserve the leader's ability to use all available information. Ideally, the leader should not have any physical tasks, but instead should delegate them all. The leader and team should operate like a dynamic "wheel hub with spokes", with the leader at the center delegating tasks and receiving information. Of course, the leader should also solicit input from team members, since it is not uncommon for a data stream to be missed. In the case above, the attending anesthesiologist for the surgery identified herself as the leader, announced the working diagnosis (shared situational awareness) to the entire OR team and called for additional help. Upon arrival of the additional help, physicians and nurses were each delegated a specific role by the team leader. Through a coordinated and stepwise fashion, supportive measures and therapeutic steps were assigned, with a deliberate effort to distribute the cognitive and physical task load that we will describe below. As mentioned above, closed loop communication was used to ensure task distribution and completion. Closed loop communication has the advantage of facilitating the cognitive unloading of the team leader's attention.

Allocation of attention

Because the environment of the operating room provides multiple data streams of information with frequent distractions from a variety of external inputs, such as alarms, conversations, and music, it can be challenging to allocate attention to the most important aspects that are relevant to patient care [15–17]. Interruptions and distractions degrade situational awareness and are well known as factors which interfere with prospective memory [18]—that is, with the intention to do something in the future, such as restart an infusion or resume mechanical ventilation, when you have temporarily stopped that action for a period of time. During crises, allocation of attention is particularly challenging because many interventions and decisions require simultaneous attention, while remembering to check the results of those interventions and decisions also need attention. This cognitive load is usually sufficient to overwhelm most individuals. As such, one method to enhance allocation of attention is to unburden the team leader with the tasks requiring prospective memory and move to a distributed cognition [19, 20]. For example, during the above-mentioned case an arterial blood gas needed to be drawn and sent to the lab and the results checked when they became available. To share the prospective memory cognitive load, the team leader delegated a specific team member to collect and send the sample and also to follow up with the labs and report back with the results. This simple step of shifting the cognitive responsibility for lab results from the leader to a delegate ensured that prospective memory did not fail while freeing up the leader's attention for other tasks requiring attention.

Use all available information

In perioperative medicine, information abounds that is not explicitly presented to the anesthesiologist. Surgeons use a variety of tools, devices, and medications on the surgical field, often without communicating with the anesthesia team [21]. A cacophony of ever-present, but various, alarm tones can lead to alarm fatigue [22] and the failure to recognize real indicators of physiologic derangements. Conversations pertaining to patient care occur among OR staff that are sometimes not heard by the anesthesiology team. The working memory capacity of the human brain and the associated concepts of cognitive load theory limit the amount of data that can be recognized and synthesized at a given time, so it is not surprising that no one individual in the OR can be fully aware of all the possible data. However, a comprehensive capture of all of these sources of information is required to truly maintain situational awareness. Therefore, an attitude of skepticism, for instance by assuming all alarms are true until they are proven false, can allow for a greater margin of safety. Actively seeking information from team members, rather than assuming others will relay it, helps to gain information and raise situational awareness. Additionally, tasking a helper to monitor specific information streams (such as having the circulating nurse update the anesthesia team with the estimated blood loss hourly) may help to avoid fixation error by the leader, who may be perceptually blind to some information if hyper-focused on other data [23, 24].

Distributing workload

Based on an understanding of the limits of working and prospective memory, as well as of attention allocation, it follows logically that "closed loop" communication not only reduces the potential for communication failures but is also critical for effective distribution of workload. Role clarity goes hand-in-hand with the concept of distributed workload, and both are intended to cognitively unburden the team leader so specific tasks can be managed by other team members according to their capabilities and strengths. For example, an intensivist physician is better delegated to obtain central venous access, while junior medical or nursing personnel might be best assigned the labor-intensive, but not highly skilled, task of mixing dantrolene. The purpose of this unburdening is to free cognitive bandwidth for processing and responding to the dynamics of an evolving emergency, evaluating the effectiveness and significance of the response to treatment, and anticipating and planning the next steps. Although this tenant of CRM may seem obvious, it is apparent in both event-reporting (e.g. the Joint Commission sentinel event reports[1]) and shared personal experience (e.g. responding to a "code blue" on a hospital floor) that disorganization of roles and tasks is frequent, while coordinated and calm management is rare. An example of distributing the workload in a coordinated fashion for the case described here was to assign the same team

[1] http://www.jointcommission.org/sentinel_event.aspx.

member who placed the arterial line with the task to also draw blood and send the samples to the laboratory for testing and then check on the results of these lab tests. In this way, the leader needed only to ask once and could turn her attention elsewhere, knowing that the data would be obtained and relayed without further effort. Additionally, an attending anesthesiologist who was facile with central line placement was assigned the role of getting additional intravenous access, while multiple nursing staff members were given the roles of mixing the dantrolene required to treat the patient.

Effective communication

Keeping the team apprised of changes in the clinical status of the patient is critically important. Along the same line as "situational awareness" and allocating attention wisely, while still maintaining vigilance over all potentially available information, frequent updates allow team members to make more effective contributions (e.g., making suggestions based on lack of patient response to therapy). An important component of good CRM practice is the continuously updating of the team by the team leader about what has been done, how the patient has responded (or failed to respond), and what still needs to be done, all the while soliciting input and ideas from team members. Not only does this make a valuable contribution towards best patient care, it also fosters a favorable sense of team cohesiveness, which is an important element for individual psychological and emotional well-being after a critical event [25, 26].

Best practices for "calling for help"—when and how

Although many training programs teach anesthesiologists that it is never to early to call for help, there are often barriers that preclude anesthesia providers from calling for help in time to make an actual difference to patient outcomes. This harkens back to the concept of anticipation and effectively calling for help in the "pre-code" state. This is both literal and metaphorical, as there are emergencies that do not evolve into arrests and those that do. The key message is to call for help early enough so that the worst outcome is avoided. Table 2 reviews Gaba et. al.'s [14] suggested triggers for requesting help.

It is particularly common in large hospitals for too many people to respond to overhead calls for help, which can make role clarity and workload distribution challenging. And even if numerically there may not be too many responders, there may appear to be too many because tasks are not explicitly assigned and, consequently, personnel attempt to be useful in a disorganized way. We recommend that when help arrives, the leader identify whether "hands help" (physical tasks) or "head help" (thinking) is needed, briefing each responding person accordingly upon arrival. For "hands helpers", who might perform tasks such as performing chest compressions, a full context briefing is not necessary and may actually be a waste of time. For "head helpers", whose task is to aid in diagnosis or suggest alternatives to failing therapy, critical information obviously must be relayed. However, the helper will be best able to assist if he or she is briefed first (before conveying clinical history) that diagnostic or therapeutic decision help is needed. This allows the helper to engage in the appropriate mental model immediately upon arrival. In the MH case, a second anesthesiologist was called to assist when the early, nonspecific abnormalities persisted despite seemingly appropriate therapy. This resulted in earlier and more definitive diagnosis of MH than might have otherwise occurred and also allowed for quick decision support as the team worked through diagnostic and treatment decisions, including the mobilization of further resources. The subsequent helpers, the "hands helpers", were then called to complete tasks, such as placing additional intravenous lines and monitors, preparing and administering medications, placing a Foley catheter, sending the specimens to the lab for testing, activating cooling measures, monitoring specific derangements (e.g. advise the team leader of electrocardiogram changes), documenting medications administered, keeping track of time, arranging for the appropriate next phase of care [e.g. obtain an bed in the intensive care

Table 2 General criteria for when help is needed (for all anesthesia providers)

The patient's condition is.....	Or when you, the primary anesthesia professional.....
Already catastrophically bad (e.g. cardiac arrest; "cannot intubate and cannot ventilate"	Need to accomplish more tasks in less time
Bad and getting worse (e.g. "cannot intubate and getting harder to ventilate")	Are overloaded with task demands
Not responding to the usual treatments (e.g. hypotension, ST segment depression)	Are not sure what's going on and need a second opinion
Known to require help to deal with (e.g. major trauma, MH)	Are asked by another team member if you want some help (if they ask you, chance are you could probably use the help)

Adapted from Gaba et al. [14]

unit (ICU)], administering cardiopulmonary resuscitation if needed, calling the MH hotline, consulting the emergency manual, and following up with the leader on the status of these tasks.

Mobilize resources

This concept goes hand-in-hand with calling for help and encompasses not only calling for human help but, when needed, also the help of specialized personnel (e.g. perfusionist if cardiopulmonary bypass is required) and specialized equipment (e.g. cardiopulmonary bypass machine). We would be remiss if we did not emphasize that this step, like calling for help, must happen early enough to make a difference. Delays in actions, including mobilizing the appropriate resources, are common and contribute to a large portion of preventable patient harm [27].

Decision-making support and cognitive aids

A paradigm shift has been occurring in medicine over the past two decades. As the already enormous amount of knowledge increases exponentially, it is generally accepted that not all medical knowledge and information will be readily accessible at the forefront of one's mind, particularly during an emergency. Of course, being able to institute supportive therapy will always be essential knowledge for the anesthesiologist. However, because specific emergencies are generally rare, such as MH, it is unlikely that any physician will have the unfortunate experience of becoming expert in any of these [5]. Moreover, it is well known that cognitive performance declines under circumstances of high-stakes outcomes, time pressure, and other stressors. Despite extensive didactic knowledge (and perhaps also simulation training), the stress of an emergency is known to degrade cognitive performance, particularly with regard to recall and prospective memory [28–30]. Cognitive aids can be of great value under these circumstances; however, they can also be rendered useless if implementation is inappropriately employed [31–33]. As such, there has been an increased interest in best practices of the implementation of cognitive aids and other decision-making support tools (checklists, manuals, algorithms, apps, literature, colleagues, and consults). Simulation studies and "real world" studies [34–36] have shown that critical steps are missed less often when such aids are used. Additionally, some have suggested that cognitive aids may be even more useful when there is the delegation of a "reader", whose specific role is to appraise the leader of the items on the cognitive aid being consulted. Burden et al. [36] evaluated the impact of introducing a dedicated "reader" role during a simulated crisis. In their study, the reader's sole responsibility during the crisis was to consult the cognitive aid and verbally confirm the completion of steps. The investigators observed that critical steps in management were missed in all scenarios without a reader, even among the trainees who had access to and used a cognitive aid. However, in the group with access to the cognitive aid and a dedicated "reader", 100 % of the critical steps were performed correctly. Of course, cognitive aids are most effective if the user is already familiar with their whereabouts and format and if the culture supports their use. In this particular case, a first-year anesthesiology resident was delegated to consult the MHAUS cognitive aid for MH and review the treatment recommendations (http://www.mhaus.org/healthcare-professionals/managing-a-crisis) aloud with the leader. Notably, the "reader" does not require specialized medical knowledge. The aim of the "reader" is not to supply medical judgment or replace the team leader, but simply to unburden the leader from having to direct attention to consult the resource himself or herself. The leader is expected to incorporate the information provided to them by the "reader" and make the ultimate treatment decisions and delegations. And of course, additional expert consultation for another opinion ("head help") is a form of decision-making support that has long been endorsed. Thus, even with effective decision support, the leader is ultimately responsible for clinical and diagnostic decisions, including choosing to modify an algorithm or switch to a different algorithm altogether.

Know the environment

With the ever-increasing amount of anesthetizing locations, familiarity with the environment is becoming more important for making decisions on safe patient care. Although the particular case described here occurred in a main operating room, not all anesthetizing locations routinely stock dantrolene due to cost (for more discussion on 'how much safety we can afford' see Newman-Toker's economic perspective [37]). Moreover, many locations do not have a sufficient amount of staff to manage such a large-scale emergency. It is worth noting that anesthesia technicians are key support personnel at our institution, and we rely upon them to bring equipment on a regular basis. Even with that luxury, it is the obligation of the anesthesiologist to know the environment so that he or she can obtain rarely used equipment, such as the charcoal circuit filters recommended by MHAUS in this case, without delay [38].

Resolution

Due in part to timely, well-coordinated, thorough event management, the patient in this case had an excellent outcome. Although he met criteria for the highest degree of certainty possible for diagnosing MH according to Larach and colleagues' grading scale [39], within approximately 24 h from the initial onset, the patient had complete resolution of signs and symptoms of MH. He was ultimately discharged from the ICU 3 days after the onset of the critical event and suffered no long-term sequelae.

Summary

Malignant hyperthermia is one of many rare but potentially devastating diagnoses that may be encountered across the various medical specialties. Factual knowledge alone is likely to be insufficient to orchestrate the timely and comprehensive management of such a case. Moreover, most physicians will not likely have the misfortune of personally experiencing a given rare emergency more than once or twice in a career. Therefore, acquiring expertise in crisis resource management may be the critical element that ensures expert physician performance when rare emergencies arise. Although these principles are not complex or overly sophisticated, they are often poorly executed. Subsequently, this can lead to a delayed or missed diagnosis, incomplete application of best practice guidelines, and ultimately patient harm that may have been preventable.

Compliance with ethical standards

Conflict of interest None.

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